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Editorial

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Many studies mapping, modelling and valuing ecosystem services (ES) focus on a set of ES for a specific region or nation. Frequently, such studies choose a geopolitical or topographical border as their system boundary both for practical reasons and possibly assuming that regions are closed systems. Most geographical regions, however, are open with respect to fluxes of matter, energy and information. While national borders often limit trade and flows of people to some extent, the same does not apply for sub-national or regional boundaries. Many studies, however, neglect the dependence on interregionally flowing ES, the extraterritorial ES impact of domestic policies and thus telecouplings (Liu et al., 2013) between regions. ES are diverse and flow across space in diverse and complex manners. Some of these interactions between regions are directly embedded in trade flows, for which a large body of knowledge exists in fields that do often not explicitly study the trade of agricultural or forestry goods under the ES framework (e.g. Koellner, 2011, Yu et al., 2013, Erb et al., 2009, Kastner et al., 2011). Other flow mechanisms include migration and dispersal of species (López-Hoffman et al., 2017), beneficial biophysical flows across regions (Liu et al., 2016), avoidance of detrimental flows, and information flows (Liu et al., 2015). Regions are telecoupled with respect to the use of "overseas" ES through ES flows, and probably depend (in absence of substitutes within the own regions) on such ES flows. Coupling also takes place with respect to ecological impacts of ES management in distant regions. The importance of such interregional connections clearly limits the informative value of regionally restricted place-based assessments of ES and raises questions of interregional sustainability of ES use (Schröter et al., 2017, Kissinger et al., 2011).

Ultimately, policies should evaluate impacts beyond the region of immediate interest, to avoid undermining socio-environmental stability in complex telecoupled systems (Pascual et al., 2017). There is, hence, a need to consider such interregional ES flows between sending and receiving systems. In this special section five papers are collected which advance this field of global and interregional flows of ES. In the first paper Schröter et al. (2018) provide a conceptual framework and distinguish four different types of such flows which are illustrated with four cases on coffee trade, flood protection along the river Danube, migration of northern pintail ducks, and information flows concerning the giant panda. The presented framing connects ES thinking with the telecoupling framework and goes beyond earlier conceptual papers on spatial flows of ES (Serna-Chavez et al., 2014; Bagstad et al., 2013, Syrbe and Walz, 2012, Liu et al., 2016). The distinguished types of flows are *Flows of traded goods which* are derived from provisioning services and are transported to a receiving system. *Flows mediated by species through migration and dispersal* are provided by animals moving between sending and receiving systems, and can provide a variety of provisioning, regulating and cultural services. *Passive biophysical flows* comprise both the provision of beneficial flows (such as freshwater) and the prevention of detrimental flows (such as flooding risk) across long distances through biotic and abiotic processes. *Information flows* are received through information cognition in the receiving system, and provided by species and ecosystems in the sending systems (such as information on the existence of an iconic species). In the following papers specific flow types are further investigated.

The second paper by Fridman and Kissinger (2018) analyses the flows of agricultural commodities and the global impacts of their production on water availability and erosion regulation. Such analysis stresses the importer/receiving countries' dependency on ES in the production/sending regions, but opens also the opportunity to optimize the sourcing of commodities based on their ES impacts. In the third paper Semmens et al. (2018) investigate flows of cultural ES mediated through migratory species. The example of the Monarch butterfly shows that migration of this species links the ES sending system in Mexico with the ES receiving system in the US. The fourth paper written by Quatrini and Crossman (2018) uses the financial support to stop desertification as an indicator for global demand for ecosystem services. In the light of the framework paper this is seen as a flow of interregional co-production factors (i.e., investment transfer) between the sending system and the receiving system. The authors show that investment decisions are in favour of regions with high levels of biodiversity, carbon sequestration and wild food provisioning. The fifth paper by Drakou et al. (2018) demonstrates how different types of interregional flows combine in creating benefits for intermediate or end users. This is exemplified through mapping ES flows in tuna fisheries, where flows mediated by species combine with trade and other flows in a value chain.

These papers highlight individual mechanisms, which are covered by the framework provided by Schröter et al. (2018). While telecoupling and flow of agricultural commodities through trade systems are already studied for a long time through trade models and life cycle assessment, these methods are often insufficiently spatially detailed to allow place-based analysis of interaction with other ecosystem processes and hence limited in the potential to address potential tradeoffs between provisioning, regulating and cultural ES in agro-ecosystems. Research is certainly needed to better understand all four flow types on different spatial and temporal scales and the emergent interactions between these processes (i.e. species dispersal is, unintentionally, strongly affected by trade flows of agricultural commodities, interregional information flows on species and ecosystems might influence

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the efforts to internationally support conservation). Feedbacks between sending and receiving system are well elaborated in equilibrium approaches in Computational Equilibrium Models and in economic theory. However, to what extent demand is affected by changes in (distant) supply of ES is a knowledge gap and highly relevant in the context of unrealistically high future demands for ES while facing limited resources. While National Ecosystem Accounts and National Ecosystem Assessments (Schröter et al., 2016) have gained popularity in recent years as an operational tool to account for changes in ecosystem services the approach lacks consideration of aspects of the receiving system's dependency on distant ES and impacts on ES in the sending systems. As the consequences in the sending and receiving systems with respect to investments and impacts finally determine the interregional justice and equity of coupled regions, there is a need to extend national assessments with an interregional component. The recent assessments of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and in particular the assessment on Europe and Central Asia, have put a particular focus on interregional ES flows, but have also found knowledge gaps for flows of regulating and cultural ES (IPBES, 2018).

The papers in this issue have advanced our conceptual and empirical understanding of these flows and distant dependencies, but at the same time, many challenges remain to properly embed the characteristics of a very (tele)connected world in mostly place-based assessment methods. Next to improving assessment methodologies for the different types of ES flows and their respective impacts in the sending systems, important research questions arise around the governance mechanisms of such flows, which involves further development of policy instruments.

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